Claims

We claim:

1. A method for detecting symbols of a modulated signal received via channels of a wireless communications system, comprising:

obtaining an initial estimate of a symbol transmitted via the channels from a previous channel estimate and a received symbol;

updating the channel estimate;

optimizing the next estimate of the symbol which maximizes an expectation of a log likelihood function;

quantizing the next estimate of the symbol;

comparing the quantized next estimate of the symbol with the previous estimate of the symbol to determine if the previous estimate of the symbol and the quantized next estimate of the symbol have converged; and otherwise

repeating the updating, the optimizing, the quantizing, and the comparing until the previous estimate of the symbol and the next estimate of the symbol converge.

2. The method of claim 1 wherein the signal is a MPSK modulated signal having a positive constant equivalent to an energy of the modulated signal, and using only phase information during the updating.

3. The method of claim 1 wherein the comparing further comprises:

subtracting the previous estimate of the symbol from the next estimate of the symbol to obtain a difference; and

determining that the previous estimate and the next estimate have converged when an absolute value of the difference is less than a predetermined threshold.

4. The method of claim 1 further comprising:
obtaining the initial estimate of the symbol from the channel estimate of a pilot symbol received via the channels.

5. The method of claim 1 further comprising:
obtaining the initial estimate of the symbol from the channel estimate of a previously received symbol.

6. The method of claim 1 wherein the optimizing further comprises:
using only a fast Fourier transform matrix, the received signal, and the previous channel estimate .

7. The method of claim 1 wherein the estimate of the symbol is quantized according to the signal constellation.

8. The method of claim 1 further comprising:
determining a posterior covariance matrix $\mathbf{\Sigma}_p$ of the channels using a FFT matrix **W**, the previous estimate of the symbol, $\mathbf{X}_p$, the received symbol **Y**, and a Gaussian noise variance σ^2 as $\hat{\Sigma}_p = (\mathbf{W}^H \mathbf{X}_p^H \mathbf{X}_p \mathbf{W}/\sigma^2)^{-1}$,
determining a posterior mean $\underline{\hat{h}}_p$ of a channel impulse response as $\underline{\hat{h}}_p = \hat{\Sigma}_p(\mathbf{W}^H \mathbf{X}_p^H \mathbf{Y}/\sigma^2)$;
determining a channel update coefficients matrix **C** for recovering the next estimate of the symbol; and

applying the coefficient matrix **C** to the posterior mean $\hat{\underline{h}}_p$, the FFT matrix **W**, and the received signal **Y** according to $\underline{\tilde{X}}_{p+1} = \mathbf{C}^{-1}(\hat{\underline{h}}_p^H \mathbf{W}^H \mathbf{Y})^T$ to optimize the next estimate of the symbol $\mathbf{X}_{p+1}$.

9. The method of claim 1 further comprising:

determining a posterior covariance matrix $\mathbf{\Sigma}_p$ of the channels using a FFT matrix **W**, the previous estimate of the symbol $\mathbf{X}_\mathrm{p}$, a channel convergence matrix Σ^{-1}, and a Gaussian noise variance σ^2 as $\hat{\mathbf{\Sigma}}_p = (\mathbf{W}^H \mathbf{X}_p^H \mathbf{X}_p \mathbf{W}/\sigma^2 + \mathbf{\Sigma}^{-1})^{-1}$;

determining a posterior mean $\hat{\underline{h}}_p$ of a channel impulse response as $\hat{\underline{h}}_p = \hat{\mathbf{\Sigma}}_p(\mathbf{W}^H \mathbf{X}_p^H \underline{Y}/\sigma^2 + \mathbf{\Sigma}^{-1} E\{\underline{h}\})$, where the received symbol is **Y**, and $E\{\underline{h}\}$ is a channel impulse response;

determining a channel update coefficients matrix **C** for recovering the next estimate of the symbol; and

applying the coefficient matrix **C** to the posterior mean $\hat{\underline{h}}_p$, the FFT matrix **W**, and the received signal **Y** according to $\underline{\tilde{X}}_{p+1} = \mathbf{C}^{-1}(\hat{\underline{h}}_p^H \mathbf{W}^H \mathbf{Y})^T$ to optimize the next estimate of the symbol $\mathbf{X}_{p+1}$.

10.The method of claim 9 further comprising:

averaging a logarithm of a likelihood function over unknown parameters $\underline{h}$ of the channels during the maximizing.

11. The method of claim 1 further comprising:

modulating the signal using orthogonal frequency division multiplexing.

12. A system for detecting symbols of a modulated signal received via a plurality of channel of a wireless communications system, comprising:

means for obtaining an initial estimate of a symbol transmitted via the channels;

means for updating the channel estimate;

means for optimizing a next estimate of the symbol which maximizes an expectation of a log likelihood function;

means for quantizing the next estimate of the symbol;

means for comparing the quantized next estimate of the symbol with the previous estimate of the symbol to determine if the previous estimate and the quantized next estimate have converged; and otherwise

means for making the quantized next estimate of the symbol an input for a next iteration; and

means for repeating the updating, the optimizing, the quantizing, and comparing until the previous estimate of the symbol and the next estimate of the symbol converge.

13. The system of claim 12 wherein the signal is a MPSK modulated signal having a positive constant equivalent to an energy of the modulated signal, and using only phase information during the updating.

14. The system of claim 12 further comprising:

means for subtracting the previous estimate of the symbol from the next estimate of the symbol to obtain a difference; and

means for determining that the previous estimate and the next estimate have converged when an absolute value of the difference is less than a predetermined threshold.

15. The system of claim 12 wherein the initial estimate of the symbol is obtained from a pilot symbol received via the channels.

16. The system of claim 12 wherein the initial estimate of the symbol is obtained from a channel estimate from the previous symbol.

17. The system of claim 12 further comprising:

means for determining a posterior covariance matrix $\mathbf{\Sigma}_p$ of the channels using a FFT matrix **W**, the estimate of the previous symbol $\mathbf{X}_p$, the received symbol **Y**, and a Gaussian noise variance σ^2 as $\hat{\Sigma}_p = (\mathbf{W}^H \mathbf{X}_p^H \mathbf{X}_p \mathbf{W}/\sigma^2)^{-1}$,

means for determining a posterior mean $\underline{\hat{h}}_p$ of the channel impulse response as $\underline{\hat{h}}_p = \hat{\Sigma}_p (\mathbf{W}^H \mathbf{X}_p^H \mathbf{Y}/\sigma^2)$;

means for determining a channel update coefficients matrix **C** for recovering the estimate of the next symbol; and

means for applying the coefficient matrix **C** to the posterior mean $\underline{\hat{h}}_p$, the FFT matrix **W**, and the received signal **Y** according to $\underline{\tilde{X}}_{p+1} = \mathbf{C}^{-1}(\underline{\hat{h}}_p^H \mathbf{W}^H \mathbf{Y})^T$ to maximize the estimate of the next symbol $\mathbf{X}_{p+1}$.

18. The system of claim 12 further comprising:

means for determining a posterior covariance matrix $\mathbf{\Sigma}_p$ of the channels using the FFT matrix **W**, the estimate of the previous symbol $\mathbf{X}_p$, a channels convergence matrix $\mathbf{\Sigma}^{-1}$, and a Gaussian noise variance σ^2 as $\hat{\mathbf{\Sigma}}_p = (\mathbf{W}^H \mathbf{X}_p^H \mathbf{X}_p \mathbf{W}/\sigma^2 + \mathbf{\Sigma}^{-1})^{-1}$;

means for determining a posterior mean $\underline{\hat{h}}_p$ of the channels impulse response as $\underline{\hat{h}}_p = \hat{\mathbf{\Sigma}}_p(\mathbf{W}^H \mathbf{X}_p^H \underline{Y}/\sigma^2 + \mathbf{\Sigma}^{-1} E\{\underline{h}\})$, the received symbol $\mathbf{Y}$ and $E\{\underline{h}\}$ is a channel impulse response;

means for determining a channel update coefficients matrix $\mathbf{C}$ for recovering the estimate of the next symbol; and

means for applying the coefficient matrix $\mathbf{C}$ to the posterior mean $\underline{\hat{h}}_p$, the FFT matrix $\mathbf{W}$, and the received signal $\mathbf{Y}$ according to $\underline{\tilde{X}}_{p+1} = \mathbf{C}^{-1}(\underline{\hat{h}}_p^H \mathbf{W}^H \mathbf{Y})^T$ to maximize the estimate of the next symbol $\mathbf{X}_{p+1}$.

19. The system of claim 12 wherein a logarithm of a likelihood function over unknown parameters $\underline{h}$ of the channels is averaged during the maximizing.

20. The system of claim 12 wherein the signal is modulated using orthogonal frequency division multiplexing.